

LIFE CYCLE COST ANALYSIS FOR NEW BUILDINGS OR ADDITIONS
FORWARD

This document presents standards, guidelines and evaluation formats for implementation of the requirements of CGS Section 16a-38, regulations concerning energy use in State buildings. It supersedes two previous documents titled: "Energy Systems Life Cycle Cost Analysis for Building Project Funded By The State of Connecticut" which took effect on January 1, 1986; and "Energy Performance Goals For New and Existing State-Owner and Leased Buildings", which took effect on January 1, 1986.

An important consideration for design professionals is that they explore fully all reasonable viable alternate designs which might contribute to energy conservation.

REFERENCES

While the intention of these guidelines is to give as much flexibility as possible to the person preparing the analysis, certain codes and standards must be consulted. Some of these are:

1. Latest edition of the State of Connecticut Building Code.
2. ASHRAE/IES Standard 90.1-1989 W/User's Guide
3. Life Cycle Cost Manual For the Federal Energy Management Program-NBS Handbook 135

SUBMISSION OF LIFE CYCLE COST ANALYSIS

Department of Public Works' Projects shall have all required LCCA submittals through the appropriate DFW Agency Team Member. The DFW Team will transmit the original copy of the Life Cycle Cost Analysis (once approved by DFW Engineering) to the Director of Energy, Office of Policy and Management for their approval.

All State Funded projects such as, Schools, shall submit all necessary forms to the Department of Public Works, Engineering 165 Capitol Avenue, Hartford, CT 06106, Room 460 Attn. Chief Engineer, with a complete copy to the Director of Energy, Office of Policy and Management, 80 Washington Street, Hartford, CT 06106.

A Life Cycle Cost Analysis (LCCA) Determination Form (designrev 195) shall be submitted within 30 days after the scope meeting with the Agency or Town Building Committee. This form shall be reviewed by the Department of Public Works and shall inform the A/E whether a Life Cycle is required or not. The form is located in the A/E Manual Chapter 2 Page 18, and the back of this document.

If a LCCA is required, 3 copies shall be submitted in separate bound package along with Schematic Design documents. DFW shall review the documents for the intent to select the appropriate systems for the building by comparing 3 conventional systems based on Life Cycle Cost, initial Capital Costs, Fuel Usage, Fuel Costs, Operating and Maintenance Costs. All systems being compared shall adhere to the Energy Standards adopted by the State of Connecticut.

The Director of Energy of the Office of Policy and Management (OPM) will review the documents for compliancy with the OPM/State Energy Policy and passive solar. OPM will be required to notify DFW in writing with approval, disapproval or comments in 30 days.

INQUIRIES

Questions regarding the preparation of a Life Cycle Cost Analysis may be directed to the Chief Engineer, Department of Public Works, Design and Review at (860) 566-5044.

LIFE CYCLE COST ANALYSIS FOR NEW BUILDINGS OR ADDITIONS

DISCUSSION

The purpose of this document is to ensure the projects compliance with the State's energy policies regarding both Energy Performance Standards and Life Cycle Cost Analysis. The LCCA requires written approval from the Department of Public Works and the Office of Policy and Management, Energy Division. An additional goal is to provide specific design phase and construction phase energy related data on the plans to improve communication among various Design Team Members.

The objectives of this process are to ensure that:

1. The passive solar aspects of the building's sitting, glazing and envelope have been evaluated to maximize passive solar benefits.
2. The Life Cycle Cost Analysis evaluates appropriate systems for the building design considering the program requirements and how the equipment will be best utilized to reduce and simplify maintainance.
3. Energy management control systems will be used where appropriate.
4. This facility's energy systems must also consider the adjacent State facilities. How does this building's energy consumption and billing rates relate to other facilities on this State campus? Does/should the campus have primary metering? Is there a central boiler/chiller plant? Should there be appropriate mechanisms for load shedding or co-generation.

The objective is to build a non-experimental, but modern energy conscious and environmentally appropriate building that minimizes to the extent practical the energy consumption and utility costs over the expected life of the building and its mechanical systems.

The process requires a team effort between the owner, the architect, and the mechanical and electrical engineers with proper discussion and evaluation of alternatives involving both the Agency's and DFW's staff.

The design goals and as constructed energy performance for the building will be confirmed within this LCCA document and will be presented on the mechanical and/or electrical drawings within the contract documents. The information will be updated as part of the "as-built" preparation and be available as part of the record drawings for the future.

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PASSIVE SOLAR DESIGN NARRATIVE

The 1993 Legislation requires the maximum practical use of passive solar. All design professionals have been exposed to these issues. There is an obligation to include passive solar where reasonable or practical. We accept that some projects are predetermined by the program or the Client Agency on issues of siting, size, shape, number of stories, material, etc. This may conflict with passive solar design objectives. These issues must be addressed by the designer in his evaluation.

The Schematic Submission shall include a narrative statement by the Architect (or Engineer) that explains this project's opportunities for passive solar design and summarizes his considerations and provide a written summary as to what passive solar systems, if any, will be incorporated.

The narrative will address such issues as Exterior glazing, the buildings orientation, natural lighting, landscaping, solar hot water systems and any other appropriate measures.

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STATE OF CONNECTICUT
Department of Public Works
165 Capitol Avenue
Hartford, CT 06106

Date Prepared _____
Date DFW Received _____

A. Project Data

1. Name _____
2. Location _____
3. Project No. _____
4. State Agency _____
5. Agency Representative _____
Phone Number _____
6. Prepared By _____
Phone Number _____
7. DFW Team Member _____

B. Building Category - Indicate new construction or renovation, with square footages.

New Construction ft² _____

Renovation ft² _____

Check one of the following:

1. School (State Owned) ()
2. School (State Funded) ()
3. State Owned Building ()
4. Other - (Specify) ()

C. Occupancy

Specify Occupancy Class per 1990 BOCA or NFPA 101

_____.

*Note: Life Cycle Cost Analysis is required to be submitted along with Schematic Design Documents in a separate package. Do not incorporate into specifications.

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D. Agency Program Requirements

Provide the following:

1. A detailed description of the Scope of Work approved by the Agency.

2. All drawings and narrative requirements shall comply with the "Checklist for Schematic Design" listed in the DPW A/E Procedures Manual.

E. Energy Goals - Energy Goals shall be based on ASHRAE Standard 90.1-1989. Refer to ASHRAE 90.1 1989 User Guide for Guidance. Show which compliance path was chosen. Provide data proving it satisfies the criteria for each section. Comply with all Basic Requirements.

1. Compliance Method Chosen _____
2. Building envelope - shall be in accordance with ASHRAE 90.1 1989 Chapter 8 or 13 dependant on the compliance path chosen.

a. Building Envelope

Gross Wall Area (or areas by orientation): _____

Fenestration Area (or areas by orientation): _____

Wall Area Below Grade: _____

Roof Area: _____

Area of Skylights: _____

Area Over Unheated Spaces: _____

Fenestration Shading Devices: _____

Opaque Wall Heat Capacity: _____

Location of Insulation in Opaque Wall: _____

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b. <u>Description</u>	<u>Compliance Requirement</u>	<u>Final Design</u>	<u>Actual Installation</u> (For As-Built)
Air Leakage Requirements	_____	_____	_____
Moisture Migration Requirements	_____	_____	_____
Lighting Power Density	_____	_____	_____
Equipment Power Density	_____	_____	_____
Occupant Load Adjustment	_____	_____	_____
Projection Factor	_____	_____	_____
Percent Fenestration	_____	_____	_____
Fenestration Shading Coefficient	_____	_____	_____
"U" of Fenestration	_____	_____	_____
"U" of Glazing	_____	_____	_____
Daylighting Controls Required (Perimeter, Skylights)	_____	_____	_____
"U" of Opaque Wall	_____	_____	_____
"U" of Roof	_____	_____	_____
"U" of Wall Adjacent to Unconditioned Space	_____	_____	_____
"U" of Floor Over Unconditioned Space	_____	_____	_____
"R" Wall Below Grade	_____	_____	_____
"R" Unheated Slabs/Length	_____/____	_____/____	_____/____

c. Compliance Method Chosen Pass _____ Fail _____

d. Has passive Solar been maximized for this building's design and program requirements _____ Yes _____ No

e. Describe how this building design maximizes passive Solar considerations. _____

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f. If the passive Solar design exceeds ASHRAE 90.1 requirements provide the following on a separate page:

1. Capital Costs of implementing the Solar requirements.
2. Net energy savings from winter heat gain versus summer cooling gain.

3. Auxiliary Systems and Equipment as required per project

a. <u>Description</u>	<u>Compliance Requirement</u>	<u>Final Design</u>	<u>Actual Installation</u> (For As Builts)
Transportation Systems	_____	_____	_____
Freeze Protection System	_____	_____	_____
Retail Food/Restaurant Refrigeration	_____	_____	_____
b. Compliance Method Chosen	Pass_____	Fail_____	

4. Lighting Loads - shall comply with Chapter 6 of ASHRAE 90.1.

a. Exterior Lighting
Designed Levels of Illumination: _____

b. <u>Description</u>	<u>Compliance Requirement</u>	<u>Final Design</u>	<u>Actual Installation</u> (For As Builts)
Illuminated Area(s)	_____	_____	_____
Unit Power Allowance(s)	_____	_____	_____
Exterior Lighting Power Allowance (ELPA)	_____	_____	_____
Connected Exterior Lighting Power	_____	_____	_____
Controls	_____	_____	_____

* Connected Exterior Lighting Power shall be less than or equal to ELPA

c. Interior Lighting
Designed Levels of Illumination: _____

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d. <u>Description</u>	<u>Compliance Requirement</u>	<u>Final Design</u>	<u>Actual Installation</u> (For As-Builts)
Gross Lighted Area	_____	_____	_____
Listed Space Area(s)	_____	_____	_____
Unlisted Space Area(s)	_____	_____	_____
Area Factor(s)	_____	_____	_____
Unit Lighting Power Allowance(s)	_____	_____	_____
Interior Lighting Power Allowance (ILPA)	_____	_____	_____
Connected Lighting Power (CLP)	_____	_____	_____
Lighting Wattage Controlled	_____	_____	_____
Power Adjustment Factor(s)	_____	_____	_____
Lighting Power	_____	_____	_____
Control Credits (LPCC)	_____	_____	_____
Adjusted Lighting Power (ALP)	_____	_____	_____

* CLP or ALP shall be less than or equal to ILPA

Control Points _____

Control(s) and Equivalent

Control Points _____

e. Compliance Path Chosen Pass _____ Fail _____

5. HVAC - shall comply with Chapter 9 of ASHRAE 90.1-1989.

a. Provide Heating and Cooling Block load calculations based on procedures described in ASHRAE handbook 1985 Fundamentals Volume and the following criteria.

1. Cooling loads _____
2. Heating loads _____
3. Lighting loads _____
4. Envelope loads _____
5. Outdoor ventilation rates based on ASHRAE Standard 62 _____
6. Energy recovery systems energy savings in BTUH _____
7. Pick up loads _____
8. Process/other loads _____
9. Safety factor _____

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b. Indoor Design Conditions - In accordance with ASHRAE 1985 Fundamentals Volume

1. Summer db _____ wb _____ Winter db _____ wb _____
2. Set back times and temperatures. _____

3. Identify any areas which vary from normal design conditions or operating schedules.

c. Outdoor Design Conditions - in accordance with ASHRAE 1985 Fundamentals Volume.

1. Summer db _____ wb _____ Winter db _____ wb _____
Compliance Final Actual

d. <u>Description</u>	<u>Requirement</u>	<u>Design</u>	<u>Installation</u>
Duct Insulation	_____	_____	_____
Pipe Insulation	_____	_____	_____
Leakage Rates	_____	_____	_____
System(s) Cooling Capacity	_____	_____	_____
System(s) Fan Capacity	_____	_____	_____
Economizer	_____	_____	_____
Fan Power Requirement (w/cfm)	_____	_____	_____
Fan Power Control Requirements	_____	_____	_____
Piping System Friction Loss Requirements	_____	_____	_____
Pumping System Control Requirements	_____	_____	_____
HVAC Equipment(s) Efficiency Requirements at Full and Part Load	_____/_____/_____	_____/_____/_____	_____/_____/_____

e. Compliance Path Chosen Pass _____ Fail _____

6. Service Water Heating Loads - shall comply with Chapter 11 of ASHRAE 90.1-1989.

- a. Provide estimated load calculations in accordance with ASHRAE Handbook 1987 HVAC Systems and Applicators volume.

Set Points _____
Controls _____

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b. <u>Description</u>	<u>Compliance Requirement</u>	<u>Final Design</u>	<u>Actual Installation</u>
Equipment Efficiency	_____	_____	_____
Storage Insulation	_____	_____	_____
Pipe Insulation	_____	_____	_____
Controls	_____	_____	_____
Pool Covers	_____	_____	_____

c. Compliance Path Chosen Pass_____ Fail_____

7. Energy Management System

System: _____

Capabilities _____

Functions: _____

Equipment Controlled: _____

Monitoring: _____

Compliance Path Chosen Pass_____ Fail_____

F. System Concept Selection - Describe three conventional systems in detail with their mode of operation and how it may or may not benefit the proposed building design. Design shall adhere to ASHRAE 90.1-1989 and BOCA 1990. Use additional pages if required.

1. Heating System - Solar, Electric heat pump or Electric resistant heating will not be accepted unless authorized by the Chief Engineer of the Department of Public Works Design and Review.

* Ventilation - Ventilation can be provided through the main HVAC system, or could be a stand alone system.

a. Base System _____

b. Alternate 1 _____

c. Alternate 2 _____

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2. Air Conditioning - Window units, or heat pumps will not be accepted unless authorized by the Chief Engineer of the Department of Public Works Design and Review. One system shall be electric and at least one shall be Natural Gas.

a. Base System _____

b. Alternate 1 _____

c. Alternate 2 _____

3. Domestic Hot Water - Compare:

- a. Centralized system with distribution piping and recirculation (if required) with electric, gas or dual fuel.
- b. Decentralized Systems - HHW serving each floor or group of toilets.
- c. Point of Use - serving each/or group of fixtures.

1. Base System _____

2. Alternate 1 _____

3. Alternate 2 _____

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4. Lighting - One of the systems shall be part of an Energy Program either by Northeast Utilities or United Illuminating.

a. Base System _____

b. Alternate 1 _____

c. Alternate 2 _____

5. Energy Conservation Equipment. - (Air to Air HX, Dehumidification Desiccant systems, thermal ice storage etc.) - shall be considered on each project provided with a written explanation of why or why not this building could use these type of systems.

- G. Capitol and Construction Costs - Include cost estimates for all systems in accordance with the appropriate "Means Data Cost" latest edition.

- H. Annual Energy Consumption - All equipment efficiencies shall be in compliance with Chapter 5 and 10 ASHRAE 90.1-1989 or BOCA 1990.. which ever is most stringent and shall be used in calculating fuel usage.

Provide the following:

1. Calculations showing the base system and alternate system's energy usage based on the following:
- a. Electrical Consumption broken down between lighting, motors, heaters, etc.
 - b. Oil Consumption
 - c. Gas Consumption

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2. Utility Rates

- a. Energy Costs based on published rates by the Utility or existing Agency billings. Provide Utilities rate structures.
 - b. Energy Sources shall include:
 1. Gas (firm rate)_____per CCF
 2. Gas (Interruptable rate)_____per CCF. Include rules and regulations for the interruptible rate.
 3. Electric _____per KW
 4. District Heating _____ per 100 MEH
 5. District Cooling _____per ton hr.
 6. Central boiler plants for University, Hospitals, etc. shall be utilized unless they can be proven not to be cost effective. Costs shall be based on actual cost for producing and transporting 100 MEH. _____per 100 MEH.
- * Include any utility incentive programs at this time with a letter of intent from the utility company.

I. Annual Operating and Maintenance Costs

1. Provide estimated costs based on existing facility records and or manufacturers recommendations.

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SUMMARY

	Systems	Heating	Ventila- tion	Air Cond.	Hot Lighting	Water
Useful Life (years)	Base System	yr.	yr.	yr.	yr.	yr.
	Alter.#1	yr.	yr.	yr.	yr.	yr.
	Alter.#2	yr.	yr.	yr.	yr.	yr.
Total Initial Capital Cost \$	Base System	\$	\$	\$	\$	\$
	Alter.#1	\$	\$	\$	\$	\$
	Alter.#2	\$	\$	\$	\$	\$
Annual Energy Cost \$	Base System	\$	\$	\$	\$	\$
	Alter.#1	\$	\$	\$	\$	\$
	Alter.#2	\$	\$	\$	\$	\$
Annual Energy Con- sumption (BTU or KWH)	Base System					
	Alter.#1					
	Alter.#2					
Annual Operating Labor & Maintenance Cost (\$)	Base System	\$	\$	\$	\$	\$
	Alter.#1	\$	\$	\$	\$	\$
	Alter.#2	\$	\$	\$	\$	\$
Total Present Worth of 20 Years (\$)	Base System	\$	\$	\$	\$	\$
	Alter.#1	\$	\$	\$	\$	\$
	Alter.#2	\$	\$	\$	\$	\$
Total Uniform Annual Costs (\$)	Base System	\$	\$	\$	\$	\$
	Alter.#1	\$	\$	\$	\$	\$
	Alter.#2	\$	\$	\$	\$	\$

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LIFE CYCLE COST ANALYSIS

Type of System: _____

Life Cycle: 20 Years

Location: _____

Discount Rate 10 %

Architect/Engineer: _____

	Base System	Alternate #1	Alternate #2
A. INITIAL COSTS			
1. Base Cost	\$	\$	\$
2. Other Costs	\$	\$	\$
Examples:			
a. Additional construction	\$	\$	\$
b. Additional Plumbing	\$	\$	\$
c. Additional Electrical	\$	\$	\$
d. Additional Mechanical	\$	\$	\$
e. Natural Gas/Oil Tank			
Installation	\$	\$	\$
3. Total Initial Cost	\$	\$	\$
4. Difference	\$	\$	\$
B. ANNUAL OPERATING AND MAINTENANCE COSTS			
1. Fuel Cost	\$	\$	\$
2. Operating Labor Cost	\$	\$	\$
3. Maintenance Cost	\$	\$	\$
4. Other Operating Costs			
a.	\$	\$	\$
b.	\$	\$	\$
c.	\$	\$	\$
5. Total Annual Fuel Operating and Maintenance Cost	\$	\$	\$
6. Present Worth of Operating and Maintenance Costs			
(Costs) (Uniform Present Worth 20 Years 10%)			
(Costs) (8.51355) = \$	\$	\$	\$
C. TOTAL PRESENT WORTH OF 20 YEARS			
1. Initial costs	\$	\$	\$
2. Operating and Maintenance	\$	\$	\$
3. Total Present Worth Costs	\$	\$	\$
D. TOTAL UNIFORM ANNUAL COSTS			
(Total Present Worth) (Uniform Capital Recovery 20 Years 10%)			
(Total Present Worth) (0.11746) = \$	\$	\$	\$

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SUMMARY AND SIGN-OFF PAGE

The Format and Procedures as summarized below were used to demonstrate the design complies with the Energy Standards, BOCA and ASHRAE 90.1-1989, as adopted by the State of Connecticut.

I. The maximum practicable Passive Solar has been provided.	YES	NO	Compliance Method		
			Prescriptive Criteria	Syst Pref.	Energy Cost
a. Required Narrative Attached	___	___	___	___	Crit. Bldg.
II. The Lighting System is in Compliance.	___	___	___	___	___
III. The Bldg. Envelope is in Compliance.	___	___	___	___	___
IV. The HVAC System is in Compliance.	___	___	___	___	___
V. The Service Water Heating is in Compliance	___	___	___	___	___

I attest that, in my professional judgment, the LCCA has been prepared for this Project in accordance with the ASHRAE 90.1 Guidelines. This certification is based on my review of the LCCA, the design drawings and the summary computations for this project.

Name of Professional Engineer (please print)

Company

Signature

Date

P.E.#

Chief Engineer
Department of Public Works

Director of Energy
Office of Policy and Management

STATE OF CONNECTICUT
Department of Public Works
165 Capitol Avenue
Hartford, CT 06106

Submittal Date _____

Date DPW Received _____

A. PROJECT DATA:

1. Name _____
2. Location _____
3. Project No. _____
4. State Agency _____
5. Agency Representative _____ Phone Number _____
6. Architect/Engineer _____ Phone Number _____
7. DPW Team Manager _____ Phone Number _____

B. Name and Phone # of person preparing this form _____

C. Building Category - Indicate new construction, additions or renovation with square footages.

New Construction ft² _____ Addition ft² _____

Renovations ft² _____

Check one of the following:

- | | |
|-----------------------------|--|
| 1. School (State Owned) () | 2. School (State Funded) () |
| 3. State Owned Building () | 4. Other - Leased, Design Build-Turnkey. () |

D. Occupancy

Use Group or Occupancy Class per NFPA 101 or BOCA. _____

E. Agency Program Requirements

Provide the following:

1. Describe scope of work in sufficient detail as approved by the Agency:

(attach separate form if not enough space to describe)

Below to be filled out only by Public Works

The Project listed above will (will not) require a Life Cycle Cost Analysis.

Chief Engineer _____

cc: Eng File

Team File